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ADMINISTRATION OF STREET LIGHTING SERVICE

What factors need consideration in administration of a street lighting program, and how can these factors be evaluated? How can good lighting and low cost be kept in balance?

While extensive study has been made of the technical aspects of street illumination in their application to traffic safety, much less attention has been paid to the administrative aspects of street lighting. This report covers some of the major elements in a street lighting program as an administrator must consider them. Major sections of the report deal with levels of lighting, ownership and rates related to cost, financing extensions and modernization, maintenance and operation, equipment, contract provisions, records, and public relations.

Management Information Service recently obtained information on street lighting from 18 cities between 8,000 and 250,000 population. In ascending order of population they are: Alliance, Neb.; Presque Isle, Me.; Pendleton, Ore.; Winnetka, Ill.; Sarasota, Fla.; East Lansing, Mich.; Palo Alto, Calif.; Danville, Va.; Norwich, Conn.; Alhambra, Calif.; Ogden, Utah; New Rochelle, N.Y.; Lubbock, Tex.; Greensboro, N.C.; Phoenix, Ariz.; Dayton, Ohio; Richmond, Va.; and Long Beach, Calif. Data about street lighting contracts were also obtained from the cities in this group which had contracts with private utilities for power, maintenance, or a complete street lighting system.

Elements in a Street Lighting Program

Vehicle and Pedestrian Safety. The primary purpose of street lighting is to reduce accidents by increasing visibility. Figures of the National Safety Council for 1952 show that 59 per cent of the fatal accidents in cities occur at night and that the night death rate per mile of travel is three times as high as the day rate. Roadway and intersection lighting is only one factor in a complex which includes traffic density, speed, road conditions, and human variables, but the reduction in accidents that follows improved lighting has been fairly well demonstrated in a number of studies.

One of these studies was a comparison between the accident experience of 22 cities that increased their street lighting budgets in 1931 with that of 20 cities that reduced them. The group that increased lighting expenditures showed a drop in night fatalities, while the group that reduced them showed an increase. In the depression of 1932 Detroit curtailed its street lighting to 65 per cent of the 1931 output. That year the ratio of night-to-day traffic fatalities actually doubled over the 1931 ratio. Partial restoration of lighting in 1933 brought an immediate reduction in the fatality ratio.

A later Detroit study, for the period 1937 to 1940, showed considerable reduction of night fatalities as roadway lighting approached levels recommended by the Illuminating Engineering Society. These and other examples are discussed in "The Vital Importance of Fixed Lighting of Public Ways" by W. L. Cross, Jr., Preston S. Millar and R. E. Simpson in Illuminating Engineering for September, 1946.

A similar, more recent result is reported by the traffic engineer of Kansas City, Missouri. Approximately 40 miles of streets with high accident rates over a period of five years were given improved lighting. Careful analysis of accident records on these streets for a period following the lighting installation showed a slight reduction in property damage, a 40 per cent decrease in injury accidents and reduction of the night-to-day accident ratio from 9 to 1 to 1.3 to 1.

Crime deterrence is another significant objective of street lighting, particularly in residential areas where traffic accidents are not of major concern. Figures on ratio of crime to street lighting are rather scarce, but a recent limited study in Kansas City indicated a reduction in the night-to-day ratio of crimes in a newly lighted area against an increase in ratio in a previously comparable area which remained unlighted. While lighting may not per se decrease total crime it aids the police and others in observation of pedestrians and is at least a psychological deterrent to crimes against persons. A third objective of street lighting is to expedite traffic flow by better definition of physical features on the road surface and by improved readability of signs and route markers.

Levels of Lighting. "American Standard Practice for Street and Highway Lighting," published by the Illuminating Engineering Society, is the technical yardstick for street illumination. The 1953 edition is the work of the committee on street and highway lighting of the IES and has been approved by the American Standards Association. It can be obtained from the Society at 1860 Broadway, New York 23, at 50 cents per copy. Standards are based primarily on volumes of vehicular and pedestrian traffic, but special attention is given to curves, hills, intersections, railroad grade crossings, and several other classes of special hazards or conditions. Types of luminaires, mounting heights, and formulas for spacing are suggested for these various types of traffic and road conditions.

The IES standards are "for fixed lighting of a grade considered appropriate to modern requirements in the night use of streets and highways." No other standard is widely available. Recommendations are expressed in terms of rated capacity of the light source in lumens and of average horizontal foot-candles reaching the road-surface. (A lumen is the light emitted in a unit solid angle by a uniform point source of one international candle. A foot-candle is one lumen per square foot.) Although few if any cities have followed the full scope of the IES recommendations, many have adopted them for major streets. Actual levels of lighting provided vary widely from city to city and among areas in a given city. The ability of a community to pay for lighting and the desire of citizens for it generally carry as much weight as traffic conditions.

The accompanying table shows figures for lighting level and cost for 18 council-manager cities. Street lighting data have not generally been gathered or presented in this form, but the analysis is suggested as an effective means of evaluating local cost and lighting conditions. Figures in the table show a wide range in miles of streets lighted, even among cities in roughly the same population groups. They also show wide variations in levels and costs of illumination among all the cities represented. For instance, total lighting intensity expressed as average lumens per mile ranges from 30,800 to 267,000 with a median of 67,000 for the 15 cities in the table. Annual cost per lumen runs from 0.348 cents to 1.662 cents, with a median of 0.670 cents.

On a 30 foot street with "very light" vehicle traffic and "light" pedestrian travel, IES standards would call for 110,000-132,000 lumens per mile. This is the lowest level of lighting recommended, but it is 64 to 97 per cent

STREET LIGHTING DATA FOR 18 CITIES
October, 1953

City	Population (in thousands)	Miles Lighted	Total Lumens* (in millions)	Avg. Lumens* Per Lighted Mile (in thousands)	Lumens per Capita	Total Annual Cost	Annual Cost per Capita	Annual Cost per Lumen (in cents)
Alliance, Neb.[1]	7.9	16.6	4.47	267.0	566	$ 28,278	$3.58	0.633
Presque Isle, Me.	9.9	24.0	0.74	30.8	75	8,100	.81	1.094
Pendleton, Ore.[3]	11.7	38.8	1.92	49.5	164	6,500	.55	0.348
Winnetka, Ill.[1]	12.1	51.5	1.92	37.3	159	19,822	1.64	1.030
Sarasota, Fla.[3]	18.9	57.8	1.94	33.6	103	29,000	1.54	1.496
E. Lansing, Mich.[2]	20.3	26.7	1.79	67.0	88	12,000	.59	0.670
Palo Alto, Calif.[2]	25.5	105.0	6.40	61.0	252	70,253	2.75	1.095
Danville, Va.[1]	35.1	75.0	12.10	161.4	345	56,000	1.59	0.464
Norwich, Conn.[1]	37.6	83.1	6.85	82.4	182	58,442	1.55	0.854
Alhambra, Calif.[3]	53.5	132.4	11.71	88.5	219	70,607	1.32	0.602
Ogden, Utah	57.1	145.7	7.57	52.0	132	50,000	.87	0.660
New Rochelle, N.Y.[2]	59.7	170.0	7.23	42.5	121	120,225	2.02	1.662
Lubbock, Tex.[1]	71.7	83.0	15.45	186.0	216	76,821	1.07	0.496
Greensboro, N.C.	74.4	--	7.87	--	106	64,830	.87	0.823
Phoenix, Ariz.[3]	129.2	--	31.58	--	242	190,000	1.46	0.601
Dayton, Ohio	243.9	--	36.75	--	139	--	1.15	0.830
Long Beach, Cal.[3]	250.8	600.6	61.39	102.0	238	410,388	1.59	0.668
Richmond, Va.[1]	230.3	495.0	40.38	81.5	175	170,540	.74	0.422
Median	--	--	--	67.0	175	--	1.46	0.670

(Source: Questionnaire distributed by Management Information Service.)

*Lighting engineers distinguish between rated lumens of a lamp, initial lumens when installed, maintained lumens (average lumen output during its service life), and effective lumens on the road surface. It is assumed that the figures in this table are for rated lumens, which may be substantially higher than maintained or effective lumens.

1. City owns electric plant and lighting system.
2. City owns lighting system.
3. City owns part of lighting system.

greater than the median level provided by the above cities on all lighted streets. (To furnish this amount of light on the 26.7 miles of streets in East Lansing, for example, would require an additional $7,000 to $12,000 over present costs, assuming the per lumen cost remained constant.)

Ordinarily, cost per lumen should decrease as lumen output increases. This will generally be true within a single city although it is not always the case on an intercity basis, as shown in the table. New Rochelle, with the highest per lumen cost, is tenth in order of total lumens produced, while Pendleton, with a comparatively low level of lighting, has the lowest cost of all. Figures such as these provide some basis for local comparison. They also point up the need for evaluating other factors in determining the level of lighting a community should have--factors such as character of street surfacing, crime and accident rates, availability of financing, and local costs.

City Ownership and Lighting Costs. Nine of the 18 council-manager cities replying to the MIS questionnaire on street lighting own their entire lighting systems and five others own part of the system. The American Public Works Association (1313 East 60 Street, Chicago 37) found a somewhat different ratio. Its 1953 publication, "Municipal Street Lighting Practices" ($2), shows that 26 per cent of 273 reporting cities own their street lighting systems. Eighteen per cent own part of a system with a private utility owning the balance, but in 56 per cent of the cities lighting systems are privately owned.

Ownership of the lighting system and rates charged for electrical energy are the two prime factors in street lighting economics. A city-owned lighting system--cable, wire, and poles as well as fixtures and lamps--should cost considerably less than a similar privately owned system, assuming equally efficient operation in either case.

This is the case, first, because while profit is a legitimate and significant objective of a private utility, it is not a proper objective of government. Second, while private utilities under state regulation are allowed perpetual depreciation, governmental financing normally provides only enough depreciation to keep the service in efficient operation, once the capital cost has been paid by tax or rate structures. There is no economic reason for charging citizens depreciation on their own investment, and the government exists to serve its citizens on a non-profit basis. City ownership of the lighting system may also open the possibility of achieving more favorable power rates by competitive purchase or of serving the system with low-cost energy generated at water pumping stations or sewage treatment plants.

The lower capital cost of a city-owned lighting system has been outlined in the reports of two city managers to their city councils. One report, in a midwestern city under 75,000 population, showed that the annual cost of a proposed street lighting system would be approximately one-third less under city ownership than under private utility ownership, for the same level of installed light capacity. The report also touched on additional potential savings under city ownership, by competitive purchase of electrical energy or by utilization of waste heat at the sewage treatment plant to generate part of the required street lighting current.

The other report, for a slightly larger city, compared the costs of major street lighting expansion under public and private ownership of the installed facilities. This report showed the cost of a city-owned system financed by general obligation bonds to be 14 per cent less on an annual basis than ownership by the utility, allowing debt service for 25 years at 2-1/2 per cent and a 1 per cent reserve for replacement of equipment during the life of the bonds.

Electric Rates and Lighting Costs. Rates charged for electrical energy comprise the second major factor and a continuing cost in street lighting administration. Related to the financial ability of the city in bad times as well as good, rates may have considerable effect on both the intensity and the extent of a street lighting system. They depend on a number of variables including labor costs, fuel costs, load factors, and diversity factors, as well as the competitive position of the utility and the bargaining position of the city. In most states, maximum rates are set by a state utilities or commerce commission.

H. I. Miller, manager of the rates and research department, Wisconsin Public Service Commission, reviewed the whole rate question in "How Municipalities and Utilities Handle Street Lighting Rates," in the American City magazine for February 1952. He noted that while rate schedules often included cost of furnishing, operating, and maintaining equipment, in addition to the energy charge, the trend was for the city or property owner to finance the capital cost of lighting equipment, limiting the utility's obligation to furnishing energy and possibly maintenance.

MIS obtained the annual costs for street lighting of 18 cities (see table). As noted earlier, since the cost of producing electrical energy drops sharply with higher output, material increases in lumen output should result in lower costs per lumen. The table shows this is not universally true. For example, Long Beach has the highest total of lumens but pays the median cost, while Dayton, with the third highest total illumination, pays more per lumen than nine other cities with somewhat lower lumen outputs. Variations may be due to actual differences in production costs such as for labor and fuel which are affected by geography, or to failure of utilities to transfer savings to their consumers, which is a function of competition. Cities with favorable power rates and therefore favorable operating costs may have either lower lighting bills or brighter and more extensive lighting than comparable cities with higher rates.

Extending the System. Fourteen of the 18 manager cities indicated that extensions to their street lighting systems are provided out of current appropriations. Three of these also use special assessments on fronting property owners. Only two cities provide for financing with bonds. The American Public Works Association reported a similar ratio in "Municipal Street Lighting Practices," which shows 55 per cent of the city-owned systems being extended by general fund or utility revenues, and 19 per cent of all 276 reporting cities using special assessments for all or part of their systems.

These figures indicate the intent of a majority of cities to provide no more new street lighting than they can afford in a period of economic prosperity. This is sound financing. It reduces to a minimum fixed annual costs for street lighting, giving greater financial flexibility against the time when economic conditions may cause reduction in available revenues, and emphasizing the importance of electric rates as the major element in operating costs.

Underground lighting cable may not be feasible in built-up sections of the city where there are no planting spaces. In these areas, the overhead lighting system may complement the regular distribution system and lights may be fixed to distribution poles to provide maximum economy. Whenever modernization and repaving of an existing street is contemplated, however, a city should consider placing all utilities underground and should give sufficient notice to telephone, electric, and gas companies to assure their cooperation when the move is made. Cities which do not require underground utilities in their utility

franchises, at least for arterial streets, should take steps to require them when the franchise is renewed. (See MIS Report 109, Administration of Utility Franchises.)

The relative advantages of incandescent and mercury vapor lighting have become involved in considerable controversy. Because of the high light output of the mercury vapor systems, however, the question is practically limited to major streets requiring high illumination. Generally this is a small but important fraction of the total lighting system. One of the problem factors is color. The yellow-white hue of incandescent light is the accepted norm while the newer bluish white of mercury vapor, which accentuates the blue-green end of the spectrum is frequently criticized. Neither lamp affects visibility adversely, but color visibility is generally better under mercury lights when the lighting level approaches the recommendations of the IES for heavily traveled roadways. A new type of mercury vapor lamp using higher pressure mercury tubes gives a much improved color-spectrum over older mercury lamps.

The other factor is cost. Cities reporting in the APWA survey of street lighting practices were about evenly divided on the question of whether or not mercury vapor lighting cost more than incandescent. Initial cost of mercury vapor on a multiple system may be higher since lamps cost more and each lamp requires a ballast which adds about 15 per cent to total cost of each fixture. However, operating costs are considerably lower. Lamps last one-third longer to twice as long as incandescents and either (a) deliver on the order of twice the lumens or (b) operate on half the power for the same lumen output. In addition, cities operating series circuits require transformers for incandescent lighting, at a cost that approximates mercury vapor ballasts.

Maintenance and Operation. The APWA survey showed that maintenance and operation of city-owned lighting systems is generally handled by city forces, while private utilities maintain systems they own and some in which there is joint ownership. The MIS questionnaire indicated a variety of organizations among city-owned systems. In five cities, the city-owned utility handles maintenance; in two an electrical department, in three the street or public works department, in one the department of service and buildings and in another the department of engineering and public service.

Actual handling of operating equipment depends largely on types of circuits in use. The APWA found series (high-voltage) lighting systems about six times as frequent as multiple (low-voltage) systems, but 40 per cent of the reporting cities indicated use of both series and multiple circuits. The series systems require high voltage equipment and skilled high-voltage linemen, while multiple systems require only the normal precautions associated with house current.

In order to burn at full efficiency, incandescent lamps need to be replaced within a time interval somewhat less than their rated life. The APWA study shows that 43 per cent of 210 cities make group replacements on this basis. Only 32 per cent of the city-owned systems handle replacements this way, but 50 per cent of the privately owned systems make group replacements and the APWA states that the trend is in this direction.

Periodic cleaning of fixtures is also necessary. Frequency of cleaning is determined somewhat by local conditions. Proximity of certain lights to soot-producing industries, for instance, may dictate more frequent cleaning than is required in the remainder of the community. The APWA survey shows that 30 per

cent of 195 cities clean glassware annually, 28 per cent semi-annually, and 8 per cent quarterly. The other 34 per cent follow a variety of longer and shorter periods.

Some communities may still follow the practice of turning off certain lights at midnight. This is not recommended for new installations. It effects no significant saving in energy costs (lights burning between midnight and dawn are in the off-peak period of lowest cost) or lamp life (which is affected by number of starts as well as total burning time), and it requires separate control circuits which add considerably to the cost. Convenience to motorists, pedestrians, and emergency personnel on night duty should outweigh minor savings which might be achieved by the practice.

Street-tree care is another maintenance aspect of street lighting. The IES "American Standard Practice for Street and Highway Lighting" recognizes this by devoting a section to forestation. Pruning to preserve tree beauty and at the same time permit maximum lighting effectiveness should receive careful attention. Tree control for lighting is best performed as one aspect of a coordinated program of planting, care, and removal of trees and shrubbery. Such a program is discussed by Edward H. Scanlon and Kirk M. Reid in "Street Lighting Correlated with Tree Management," in Traffic Quarterly for October, 1947. Elements of a comprehensive tree program are currently covered in "Street Trees for Cities," published by the League of Oregon Cities and University of Oregon, Eugene, and "Planting, Maintenance, and Removal of Trees from Streets," by the Association of Washington Cities and University of Washington, Seattle.

Equipment. Street lighting fixtures and equipment change widely over a period of years. Some becomes obsolete before wearing out. Not long ago upright standards were considered adequate for lighting, but the present tendency is to prefer pendant fixtures. The purpose of these is to direct all useable light to the road surface rather than to dissipate it horizontally and upwards. Lights of the pendant type are said to be three times as efficient in this respect as uprights.

Along with the pendant feature, luminaires are currently mounted at heights of 25 to 30 feet. Globes are cast of clear glass with a complex of prisms that focus the light in certain predetermined directions. The total result of highmounting and focused light is to reduce glare at the light source, to concentrate the light on the road surface where it will be most effective, and to spread it uniformly from one luminaire to the next. At intersections the light may be directed four ways, into each of the four approaches or crosswalks. Lighting engineers may choose any of several luminaires with different light patterns to meet varying street layouts and conditions.

Poles may be obtained in various materials including aluminum, steel, and pre-stressed spun concrete. Whereas earlier generations preferred high ornamentation, present standards are generally functional in design, being straight or tapered shafts unembellished by any but the simplest ornamentation. Costs may vary widely with locality and market conditions. Unless a city has need for poles of a certain type, specifications should be kept open to promote maximum competition in bidding.

The utility that provides residential electric service is also frequently the one that furnishes street lighting. Consequently, residential lighting in many communities can now be serviced by low-voltage underground circuits that tap in to the utility distribution system at various locations. The proximity of these general service lines reduces the cost of underground circuits.

Underground systems for lighting are generally preferable to overhead wiring. Absence of transmission and aerial cables, including those for traffic lights or police and fire alarms, greatly enhances the appearance of a community--a factor every official should be concerned about. There is no interference or compromise with the street tree program and the system is not affected by adverse weather. Initial cost of an underground system is somewhat higher than a comparable overhead system, but if a city eliminates the costs of profit and depreciation by owning the system, as suggested above, its citizens may conclude that the final expense is worth the beauty it provides.

Contract Provisions. The contract between the city and the utility for provision of street lighting service should specify rates and operating conditions in some detail in order to prevent misunderstanding and to protect the public interest. Rates may be expressed in several different ways, the three most common of which are as follows: (a) a fixed investment charge per lamp plus a per-lamp or per-foot-of-circuit service charge for maintenance, plus an energy charge in kilowatt hours; (b) a fixed charge per lamp covering both investment and maintenance, plus the energy charge; (c) a flat charge per lamp covering all costs and varying with lamp size and type of system, whether overhead or underground-ornamental. In communities where all or part of the lighting system is city-owned, investment charges will not be included in the rate, and where city forces also provide maintenance, only the energy charge will be included in the contract.

Ten years is a common period for street lighting contracts to run. It is perhaps also the normal period over which a utility amortizes its capital investment since some contracts provide for automatic extension if the utility extends or modernizes a lighting system during the contract term. In the contracts about which MIS obtained information for this report, all 10 provided for extension of the present lighting system at city request. Six contracts provided for modernization at city request and one authorized the utility to substitute newer lighting of the same or higher light output at its discretion. Modernization was not covered in three of the contracts.

All 10 contracts carried provisions regarding suspension of lighting at city request. Seven cities may curtail lighting at any time without penalty. One may do so on six months notice, one has a supplemental agreement covering the point, and one city may not suspend its lighting during the term of the contract. Adequate coverage of this point may save a city considerable embarrassment and expense if revenues should be curtailed enough to require retrenchment.

Four of the 10 contracts authorize the cities to install and own all or part of the lighting systems, or to replace obsolete utility equipment with city-owned. Two contracts authorize limited ownership--one of the downtown business district system and one of the systems for bridges and underpasses. Terms of ownership may be a crucial point in rate negotiations and should be covered in the contract to the city's satisfaction. The standard clause authorizing city purchase of the system if the utility is unable to fulfill its obligations should also be included.

Nine of the 10 contracts specified terms of annual maintenance covering cleaning of glassware and replacement of lamps. Frequency of cleaning, responsibility for replacing broken glassware, patrol to detect outages, and conditions for replacing lamps--on a group basis or when burned out--should all be explained in detail. Contracts may contain a punitive clause in case of default on any of the terms by either party.

The utility franchise is related to the lighting contract. It may be desirable to have the two run concurrently so that one is negotiated at the same time as the other. Normally a franchise runs for a longer term, however. The franchise should contain specifications regarding overhead and underground lighting in residential and business districts and should require adequate notice to the utility if removal of distribution lines from the streets is to be required (See MIS Report No. 109, Administration of Utility Franchises).

Records. Records for street lighting should indicate location, type of unit, circuit, date placed in service, energy required, and rated lumen output for every light in the system. The master record may provide space for recording date of replacement for light bulbs and dates of cleaning for glassware. In addition, figures should be obtained annually or more often on the level of lighting in lumens provided in the whole community or in certain sections, and on per capita and per lumen operating costs. Additional records should be maintained by the street lighting bureau or traffic accident bureau or both agencies working together, on hazardous locations where accident rates can be improved by lighting, and on accident rates after lighting has been installed.

Public Relations. Whenever a crime occurs or a serious accident happens at night in an unlighted area there is strong agitation for street lighting, frequently merely at the point of occurrence. This agitation is hard to resist and frequently also hard to satisfy. Once street lighting is started on the basis of special demand, the demands grow more vigorous and more frequent. If the city lacks a definite lighting policy, lighting will quite possibly be developed haphazardly at greater cost than for an effective planned program. MIS Report No. 54, "Formula for Installation of Street Lights," covers this aspect from the standpoint of individual lights. It provides certain weights for a number of inter-related factors bearing on the need for a single light in a given location as against similar needs in other locations.

"American Standard Practice for Street and Highway Lighting" gives formulas for provision and extension of a complete lighting system based on traffic and pedestrian densities. If these standards are higher than a city can afford on a city-wide basis, the options remain of either (a) adopting local modifications of the IES standards or (b) installing lighting on an area or street basis as traffic volumes, accidents, or crime rates point out the need.

In any case the first aspect of public relations is for the city to have a firm and definite policy which treats all citizens alike and which can be readily explained and supported. The second need is for a concerted program of acquainting the citizens with the street lighting plan. When a major extension or modernization of the existing system is contemplated, the entire program should be covered in newspaper releases, talks before civic groups, special enclosures with electric bills and possibly neighborhood meetings in which the need and desire for lighting are thoroughly aired.

Area-wide illumination has a two-fold purpose--to serve the specific neighborhood in which it is installed and to serve the community at large represented by those who travel into and through the lighted section. Besides improving accident and crime rates, street lighting ordinarily enhances and stabilizes property values. Nevertheless, residents in a given area may resist new or modernized lighting, especially when capital costs are to be assessed against their property. When the city at large is not likely to be seriously affected (as on an arterial street), lighting of the section may reasonably be postponed until demand catches up with opportunity.

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